AD-A215 836

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
September 1979

3. REPORT TYPE AND DATES COVERED
Final/ 15 May-14 July 1979

4. TITLE AND SUBTITLE
BIAXIAL FINITE DEFORMATIONS OF ARTERIAL AND BENOUS SEGMENTS UNDER PLUS OR MINUS Gz ACCELERATION STRESS

5. FUNDING NUMBERS
61102F
2312/D9

6. AUTHOR(S)
Xavier J.R. Avula

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Missouri-Rolla
Department of Engineering Mechanics
Rolla, Missouri 65401

8. PERFORMING ORGANIZATION REPORT NUMBER
AFOSR-TR- 1545

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR
BLDG 410
BAFB DC 20332-6448

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
AFOSR 79-0107

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Appro...
distrib...

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
Recent developments in spacecraft and high performance aircraft have resulted in the exposure of the human body to the hazards of high accelerations beyond tolerance levels. Circulatory impairment is one of the manifestations of acceleration trauma A major cause for circulatory failure is the pooling of blood in the extremities of the body. An analytical procedure to calculate the deformations of arterial and venous segments subjected to plus or minus Gz acceleration profiles is developed using a large elastic deformation theory. In the past, most models that described the cardiovascular system response to acceleration stress had considered only radial displacements of the vessel wall. In this work both radial and axial desplacements are considered to describe the pooling capacity of the blood vessels more accurately. The governing, nonlinear, partial differential equations are solved numerically by a Runge-Kutta integration method. The deformations of blood vessels are calculated for various transmural pressures and wall tractions that correspond to a range of realistic accelerations. The computations indicate that the radial displacements are large relative to the axial displacements, and that the significance of axial

14. SUBJECT TERMS

15. NUMBER OF PAGES
3

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
unclassfied	unclassified		

NSN 7540-01-280-5500

Standard Form 298 (890104 Draft)
Prescribed by ANSI Std 239-18
298-01

89 12 04 173

displacements increases beyond 30 g.

a. Research Objectives

The objective of the reported research is to determine radial and axial deformations of arterial and venous segments under dynamic fluid loads caused by blood pooling during Gz acceleration stress of the aerospace environment.

Under moderate accelerations only radial deformations were reported to be significant by several investigators. This observation is valid in the regions of the body where the blood vessels are embedded in a stiff muscular mass and strongly tethered to the surrounding tissue. In the thoracic region, where the tissues surrounding the major blood vessels are relatively soft and accommodating, axial deformation of blood vessels under Gz acceleration can be significant. Therefore, the above mentioned objective is a reasonable one. The principal investigator intends to use the results of this research in the construction of a comprehensive mathematical model of the cardiovascular system under Gz acceleration.

b. Significant Accomplishments

The arterial and venous segments are modeled as thin elastic cylindrical membranes that are capable of undergoing finite elastic deformations. The equations of motion are derived in both axial and radial directions using a theory of large elastic deformations. An exponential strain energy function which describes the behavior of an arterial tissue is selected from the available literature and used in the derivation.

The governing nonlinear, partial differential equations of motion are solved numerically by a Runge-Kutta integration method. The deformations of blood vessels are calculated for various transmural pressures and wall

tractions that correspond to a range of realistic accelerations. The radial pressures used in the calculations are in the range 100-500 mm Hg. The computations indicate that the radial displacements in blood vessels are large relative to the axial displacements, and that the significance of axial displacements increases beyond 30 g. The significance levels are subjective because of individual and local variations in the compliance of blood vessels.

c. List of Publications

An abstract of the paper entitled "Biaxial Finite Deformations of Arterial and Venous Segments Under Plus or Minus Gz Acceleration Stress" has been submitted for presentation at the 1980 ASME Aerospace Conference which will be held 13-15 August 1980 in San Francisco as part of Century 2/ Emerging Technology Conference. A journal publication will also be prepared.

d. Professional Personnel Associated with the Research Effort

Xavier J. R. Avula
Professor of Engineering Mechanics
University of Missouri-Rolla.

Because of the short duration (8 weeks) and low level of funding more professional personnel could not be associated with the project. Graduate students were also not sought to associate with the project.

e. Interactions

The major problem of constructing a mathematical model of the cardiovascular system under acceleration stress was introduced to the principal investigator during his tenure (1974-76) as National Research Council Senior

Postdoctoral Associate at the Aerospace Medical Research Laboratory (AMRL), Wright-Patterson Air Force Base, Ohio. The idea of including the biaxial finite deformations of blood vessels was discussed with AMRL personnel, especially Dr. Hans L. Oestreicher. Chief, Mathematics and Analysis Branch.

The principal investigator has been asked by Lt. Col. George W. Irving, III, Life Sciences Directorate, Air Force Office of Scientific Research to participate in the Working Group Discussions during the 1979 Review of Air Force Sponsored Basic Research in Environmental and Acceleration Physiology which will be held at the St. Louis University Medical Center on 2-4 October 1979. The research results will be discussed in the review.

f. New Discoveries, Inventions or Patent Disclosures and Specific Applications Stemming from the Research Effort

There are no inventions or patent disclosures. The specific application of the research effort will be in the construction of a comprehensive mathematical model of the cardiovascular system under Gz acceleration stress. Under high accelerations the biaxial deformations of blood vessels must be taken into consideration. This is expected to give a better model validation.

g. Other Statements

The principal investigator recommends that a comprehensive mathematical model based on the tissue mechanical properties of the cardiovascular components be constructed. The cardiovascular system models that have been constructed so far utilize properties based on electrical analogs whose behavior is not evaluated in the adverse acceleration environment. Because of the lumped nature of these analogs it is difficult to evaluate their behavior. Therefore, a model based on primitive variables and basic mechanical properties is more reliable.